

TO: All Users of ARCHIE Version 1.0

SUBJECT: Correction of Program Error -- New version of MODCON.EXE

DATE: May 23, 1990

Option "f" on the Discharge Model Selection Menu of ARCHIE provides access to an estimation procedure for the discharge rate and duration associated with the outflow of a pressurized liquid from a point more than 4 inches from the surface of the tank or other container in which it is stored. The procedure is intended for use when the temperature of the liquid is in excess of its normal boiling point and its vapor pressure is in excess of one atmosphere. It is typically applied to cases in which a pipe or other item of equipment attached to a transportation or storage container is broken or otherwise ruptured and serves as a route for escape of the liquid. In such cases, it has been found that a distance of about four inches is sufficient to permit development of two-phase flow -- a flow condition in which the discharge stream contains both liquid and vapor and which results in a peak discharge rate (on a weight per unit time basis) generally less than that associated with cases in which only liquid is being discharged. The latter scenario is addressed in ARCHIE by Option "e" on the Discharge Model Selection Menu for releases from outlets directly on the container surface or less than or equal to four inches from such a surface.

Due to a miscommunication during program development and a resulting programming error, the rate computed by ARCHIE is currently being divided by 0.62 and is thus being overpredicted by a factor of 1.613. The new version of MODCON.EXE provided herein has been modified to resolve the problem. Simply copy the new version to the location in which the old version of MODCON.EXE dated 3/21/89 can be currently found on your computer hard drive or floppy diskettes. The new version is dated 5/23/90. Users who have evaluated accident scenarios using this discharge rate procedure may wish to consider rerunning all models in the ASF files created to correct analysis results. Most models which directly or indirectly use the discharge rate for hazard evaluation purposes will predict smaller hazard than before.

Research results identified after development of the portion of ARCHIE in question permits additional guidance to be provided to users of ARCHIE at this time on how best to select a value for the "discharge coefficient for the hole" that is a required input value. This value can be manipulated if desired to greatly improve the accuracy of the two-phase flow model. Two topics need to be addressed, these being: 1) selection of a discharge coefficient based on characteristics of the inner juncture at which the pipe or other item of equipment is attached to the container; and 2) adjustment of the discharge coefficient to improve model accuracy in cases where the expected "break" is a significant distance from the container surface.

For this model, selection of a discharge coefficient depends on whether the fitting that passes through the container wall enters in such a fashion that there is a sharp edge on the inner surface of the wall around the opening, or whether the connection is rounded or otherwise shaped to smooth and facilitate the flow of liquid into the fitting or pipe. In the first instance, the appropriate value for the discharge coefficient of a "sharp edged orifice" is 0.62. The proper value for the latter case depends on how well the liquid entry is smoothed by design characteristics of the fitting, but in all cases, will be greater than 0.62 but no more than 1.0. Where such rounding or shaping

is present, it is conservative and not unreasonable in the absence of a rigorous engineering analysis to simply select a value of 1.0 for the discharge coefficient.

During development of ARCHIE, the primary objective was to develop a system that is simple to use and designed for emergency planning purposes. Thus, an inherent assumption of the model in question not explicitly stated was that any line break or rupture would take place at a point relatively close to the liquid container. In such cases, the rate of discharge will be greater than if the line break or rupture occurs a significant distance from the container, with the difference being attributable to a "slowdown" in flow caused by friction within the line or pipe. This is still a good assumption for planning purposes and should be retained. However, it appears that many users of ARCHIE are applying the program for purposes that would benefit from greater accuracy at the cost of greater complexity. What follows is addressed to these individuals. Others can skip to the last paragraph if they desire.

In a paper titled "New Experimental Technique for Characterizing Runaway Chemical Reactions", published in the August 1985 issue of Chemical Engineering Progress (a publication of the American Institute of Chemical Engineers), well-known researchers in the field, Hans Fauske and Joseph Leung, present their findings about how the rate of discharge will decrease as the length to inner diameter ratio of the line or pipe increases. Thus, for a line or pipe of fixed diameter, a greater length will lead to a lower rate of discharge (see Figure 9 in the paper and its related discussion). Essentially, the authors define a "flow reduction factor" that can be multiplied by the selected discharge coefficient prior to its entry to ARCHIE to better account for long lines or pipes. Values of this factor are listed below for a range of length to diameter (L/D) ratios, and having been read from a graph, are somewhat approximate. (Note: These particular values assume that only a small fraction of the liquid vaporizes in the line and are therefore conservative. Flow reduction factors for cases in which larger amounts of liquid vaporize are generally smaller in magnitude.)

L/D	Flow Reduction Factor
20	0.93
40	0.88
60	0.84
80	0.81
100	0.78
200	0.69
300	0.62
400	0.57

For an example, let us consider a pipe that has a six-inch diameter and an accident scenario that calls for a line break to take place 100 feet from a large storage tank. Given that there are 12 inches in a foot, we can easily compute that the length to diameter ratio for this case is 200 and that the flow reduction factor has a value of approximately 0.69. If we had selected a discharge coefficient of 0.62, we could enter a value of 0.428 ($0.62 \times 0.69 = 0.428$) into ARCHIE for a more accurate result.

All users should be advised of the fact that the Hazardous Materials Information Exchange (HMIX) computerized bulletin board system jointly operated by FEMA and the USDOT has a new area code. The number to call to access the system is now 1-708-972-3275. A HMIX users manual and technical assistance can

be obtained by calling 1-800-PLAN-FOR (1-800-367-9592 in Illinois). Topic 21 on the bulletin board is devoted to questions and comments about ARCHIE and its associated Handbook of Chemical Hazard Analysis Procedures. It can be accessed by typing "J 21" (without the quotation marks) at the main menu prompt.